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32 VICTORIA STREET
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NOTES ON RECENT MEETINGS AND EVENTS

General Meeting in London.

A joint meeting with the Institution of Heating and Ventilating Engineers was held in the Lecture Theatre of the Institution of Mechanical Engineers on Tuesday, March 1. The chair was taken by the President (Dr. S. English) at 7 p.m.

Mr. F. C. Smith presented his paper on "Illumination Levels and Comfort Conditions," in which many topics of common interest to members of both bodies were discussed, and the importance of correlating data on heating, lighting, and ventilation was emphasised.

Following a cordial vote of thanks to Mr. Smith for his paper the discussion was opened by Mr. W. W. Nobbs (senior Vice-President of the Institution of Heating and Ventilating Engineers), who expressed the pleasure of members of that body in taking part in this joint meeting. Others who joined in the discussion included Dr. S. F. Dufton, Mr. T. C. Angus, Mr. P. R. G. Oaks, Mr. J. Gilchrist, Mr. H. Lingard, Mr. A. Cunnington, Mr H. H. Bruce, Mr. G. H. Wilson, Mr. V. J. Cockerell. Mr. F. C. Smith briefly replied.

In the course of the proceedings the hon. secretary drew attention to the list of applicants for membership and the notices of forthcoming events, which were posted on the notice board for the information of members present.

Sectional Meetings.

Decorative Lighting Section.

A meeting of this section took place at Magnet House (Kingsway, London) on February 15. Visitors were welcomed by Mr. M. R. Neville, after which an address on "The Relation Between the Artistic Design and the Mechanical Construction of Fittings," illustrated by numerous lantern slides, was delivered by Mr. E. H. Penwarden. The discussion was opened by Mr. Waldo Maitland, Mr. L. R. Tucker, and Major P. A. Smith, who expressed the viewpoints of the architect, the maker of fittings, and the electrical contractor. Others who took part included Dr. S. English, Mr. J. H. F. Piper, Miss Robinson, Mr. R. R. Holmes, Mr. Robins, Mr. J. M. Barnicot, Mr. Lovell, Mr. J. S. Dow, and Mr. E. Stroud. After Mr. Penwarden had replied to the discussion a vote of thanks to him for his paper and to the General Electric Company, Ltd., for their hospitality terminated the meeting. Those present were afforded an opportunity of inspecting the display of fittings before leaving the building.

Public Lighting Section.

There was a meeting of the Public Lighting Section on February 18, when Mr. E. J. Elford (Borough Engineer and Surveyor, Wandsworth Borough Council) gave an address on "The Relighting of a Borough." Mr. J. M. Waldram presided over the meeting, which took place in the Municipal Buildings, Wandsworth, at 6.30 p.m. There was a good discussion. A cordial vote of thanks was conveyed to Mr. Elford for his address, and for his trouble in making arrangements for the occasion. Prior to the meeting, members were furnished with a plan showing the chief streets of interest, which they had thus an opportunity of inspecting beforehand.

Industrial Lighting Section.

A meeting of this section was held at the E.L.M.A. Lighting Service Bureau (Savoy-hill, London, W.C.) on February 22, when Mr. R. O. Ackerley presided. A series of varied problems in industrial lighting was presented by Mr. W. J. Edwards, Mr. A. S. M. Brackenbury, and Mr. H. N. Winbolt, and led to a keen discussion. A vote of thanks to the authors and to the E.L.M.A. Lighting Service Bureau for their hospitality terminated the proceedings.

Meetings of Local Centres.

North-Western Area Local Centre.

On February 21 a joint meeting of the Section with the Society of Production Engineers took place at the Engineers' Club, Manchester, when a paper on Factory Lighting was read by Mr. A. W. A. Thurley. There was an excellent discussion, in which the president (Dr. S. English) took part.

North Midland Area Local Centre.

At a meeting held on February 21 a paper dealing with Fluorescence and Luminescence, with special reference to the application of these phenomena to sources of light, was read by Mr. H. G. Jenkins.

Local Centre for Scotland.

The fifth meeting of the session took place in "The Gordon" (19, Gordon-street, Glasgow), on February 9, when a paper on Street Lighting was read by Mr. W. J. G. Davey. This was the first paper to be read at this centre by a representative of the gas industry, which, it is hoped, is an indication that members of the gas industry will co-operate fully with the I.E.S. movement in Scotland. Mr. Davey dealt very fully with the final report of the M.O.T. Street Lighting Committee, explaining how its recommendations could be met in connection with gas lighting, and illustrating his remarks by figures for lumen output and consumption and isocandle diagrams for various forms of gas lamps. There was an attendance of about fifty-five, of which approximately half were connected with the gas industry. Mr. H. E. de Weerdt opened what proved to be a keen discussion, in which Mr. T. M. Lappin, Mr. F. G. Nesbit, Mr. R. Campbell, Mr. E. Hood, and Mr. Hime took part. A cordial vote of thanks to the author, proposed by Mr. S. B. Langlands, terminated the proceedings.

Local Centre for the Irish Free State.

A lecture on "Lighting from the Architect's Point of View" was delivered by Mr. F. J. Ryan, in the Engineer's Hall (Dawson-street, Dublin), on February 1. The lecturer traced the evolution of design from the Victorian period up to the present day, illustrating his remarks by numerous lantern slides, and critically examining various modern types of fittings.

DECORATIVE MATERIALS AND THEIR RESPONSE TO LIGHT

By R. O. ACKERLEY *(Member)*

(Paper read on Tuesday, January 11th, 1938)

Some difficulty was experienced in selecting a title which would convey in a few words the nature of the problems or phenomena which this paper is intended to discuss. The title finally selected was a compromise between a desire to let members know what the paper was about and the necessity to describe the subject briefly. It may be well, therefore, to indicate more fully the aspect of illuminating engineering which it is hoped to cover.

Light and Decoration.

It has become more and more recognised in recent years that in any scheme of interior decoration artificial lighting is one of the most important factors, a factor which may, during the hours when artificial light is used, make or mar the general decorative effect. For this reason those who are responsible for designing the lighting system take care to ensure that the appearance of the lighting fittings is in harmony with the general decorative scheme, that the tone and quality of the lighting is appropriate, and that illumination requirements as regards intensity and distribution are reasonably provided—but in catering for all these most desirable requirements the lighting system and the general decorative scheme of paint and wall-paper and curtains and so on are considered as two separate entities which must be blended together, and the possible effect of each in changing the appearance of the other is liable to be overlooked. In effect, one is liable to take the appearance of decorations as seen in daylight, or whatever light they may be under in the decorator's shop, and decide on a lighting scheme which it is thought will harmonise with that appearance, and to forget that the materials which make up the general decorative scheme may themselves change in appearance if the system of lighting adopted differs from that under which they were originally judged.

What, therefore, it is proposed to discuss is this subject of how the appearance of those materials most generally used in interior decoration can be and almost invariably is, altered if the system of lighting is varied and, if possible, to show how lighting can be selected to enhance their appearance and to show them off to the best possible advantage. The title should be qualified by the word "artificial" before the word "light" as it is not proposed to discuss daylight effects, and as the author is a practising member of the electric lighting industry these remarks are essentially based on experience with electric lighting, though in so far as fundamentals are involved most of the conclusions would apply under any system of lighting. Finally, it should be said that the paper is based far more on practical observations made in everyday illumination work than on any attempt to examine the problem from a laboratory point of view.

Object and Light—the Variables.

Upon what then does the appearance of any object depend? There are three factors concerned: the nature of the object, the nature of the light which strikes the object, and the eye that sees the object. For the purpose of this paper, assume that the properties of the eye are constant, and that the eye is not afflicted by colour blindness, astigmatism, long sight, short sight or any other disability—that it is, in fact, a perfect human eye. With this assumption the appearance of the object is dependent entirely on the light which it reflects to the eye, and this depends on the first and second factors mentioned above, namely, the nature of the object and the nature of the light falling on it. In what manner and to what extent can variables in these two factors affect appearance?

In the case of the light, the three main variables are (1) direction, (2) degree of concentration or diffusion, and (3) spectral composition.

In the case of the object lit, the main variables are (1) specular reflecting properties, (2) diffuse reflecting properties, (3) colour, and (4) surface texture. Now information is available as to the basic characteristics of such things as a specular reflecting surface, a diffuse reflecting surface, a rough surface, a smooth surface, a coloured surface, etc., each as separate phenomena, and the response which each makes to a controlled beam of light, but it would not appear that any material study has been devoted to the consideration of the appearance under artificial light of surfaces combining the qualities of several or all of the above ingredients, and under the wide variety of light sources or systems employed in ordinary lighting practice. To appreciate the possibilities and complexity of the problem, it is desirable to consider briefly each of these components separately.

Specular Reflection.

Assume for a start, a directional beam of white light from some incandescent light source having a continuous spectrum, which for convenience will be referred to as a white light source, and imagine such a beam as falling on a more or less flat surface. Under such a beam of light a specular reflecting surface will reflect an image of the light source in one direction only: it will therefore appear bright when viewed from this direction and dark when viewed from all other directions.

Specular reflection is most familiar in the form of reflection off polished metal surfaces either direct or through glass, as in the case of silvered-glass reflectors, and in such cases the percentage of light regularly reflected is frequently very high. In decorative work there is another manifestation of specular reflection which is from a practical aspect of greater importance, namely, the spectral reflection which takes place at any highly glazed or polished surface. The total reflection from such specular sur-

faces is relatively small, but, especially at high angles of incidence, is quite sufficient in most cases to make the object appear as a true specular reflector.

Furthermore, the reflection from such surfaces among which are glossy paints, tiles, polished wood surfaces, etc., is unaffected by the colour of the reflecting surface, the reflected light remaining the same colour as the original beam, i.e., a black tile or a polished wood panel, if viewed from the right direction, will each be reflecting white light and will therefore look white. This rule does not apply in all cases of specular reflection. Polished metal surfaces reflect specularly, but selectively, that is to say, the colour of the reflected light from a white source is substantially that of the metal. This is of importance in decorative work in view of the considerable use of metallic paints and metallic threads in decorative papers and fabrics. Another exception is where the colour is in the form of a transparent medium such as a varnish laid over a specularly reflecting surface. In such cases, strictly speaking, two reflections take place, one uncoloured from the top surface and one from the back surface, which is coloured by passage through the medium. In practice the latter tends to swamp the former.

While in the case of true specular reflection a more or less clearly defined image of the light source will be visible at the relevant angles of viewing, there is another form of reflection usually known as "spread specular" which conforms generally to the laws of true specular reflection, but in which, instead of an image of the light source, an overall increase of brightness is observed at or near those angles of view at which one would expect regular reflection.

Diffuse Reflection.

Now examine the behaviour of a diffuse reflecting surface under a similar beam of light. Such a surface reflects the light in all directions so that it will appear bright when viewed from any angle, but it also reflects selectively, that is to say, the reflected light will be of the same colour as the surface. Before leaving the subject of specular and diffuse reflection reference should be made to one matter. Many of the predominantly diffuse reflectors are also capable of some specular reflection, the amount of which is affected materially by the angle of incidence of the light. At very oblique angles a very much higher percentage of specular reflection is apparent, and under such circumstances a flat paint finish, such as, for example, normally appears quite matt, may have a distinct appearance of gloss.

Coloured Light.

Now consider what happens if the colour of the light is changed by putting a colour medium over a white light source. It must be remembered that no object will show colour until light strikes it, and it depends entirely on the spectral composition of the light and the spectral absorption of the colouring matter on the object as to what colour the latter then appears. Those surfaces which gave a non-selective specular reflection will now appear, if viewed at the right angle, of the new colour of the light source; at all other angles they will continue to appear dark. Diffuse reflecting surfaces and selective specular surfaces, however, will only be able to reflect those colours which are common to both the pigment and the light source. Thus a white surface will appear the same colour as the light source, but a coloured surface will absorb any of those colours the pigment is unable to reflect, and will, unless the light is of its own colour, tend to change its colour but not to that of the light. Imagine, for example, a yellow paper capable of reflecting red and green light, and having thrown on to it a purple light made up of red and blue, the paper, being unable to reflect blue light and there being no green light to reflect, will tend to turn red.

In practice, when dealing with coloured lighting obtained by the most usual methods (e.g., by means of colour media, sprayed lamps, glass and silk or fabric shades) and ordinary commercial decorative fabrics and papers, the spectral composition of the light and the spectral absorption of the colouring matter in the material is so complex that it is only possible to estimate very approximately what the resultant appearance will be. In this connection a distinction must be made between colour and spectral composition or absorption. In the case of materials, the dye bases used, for example, in textile fabrics and wall-paper may be of so different a nature that while the colours appear to match perfectly under daylight they will appear quite different from one another under certain colours of artificial light. Equally, two different types of colour medium having different spectral transmissions but producing the same colour when light passing through them is seen reflected off a white wall may give two entirely different appearances to some coloured fabric.

While these variations cannot be ignored they are relatively small, but there is one far more important aspect of coloured light sources that has entered the modern lighting field. So far only incandescent sources of light which have continuous spectra have been considered. The advent of electric discharge lamps introduces light sources with line spectra, and the appearance of coloured materials under such sources may be very substantially different from that under a filtered white light of apparently identical colour. Only by knowing the spectral composition of the source can one anticipate the resultant appearance of any coloured material under it.

Finally, it should be realised that, due to the accommodation of the eye, the apparent shade of colour can be altered by relative light intensity. For example, a brown paint may be simply a yellow paint of low reflection factor. If, therefore, the illumination on any particular section of a decorative ensemble is increased, leaving the remainder unaltered, the colours on the more brightly lit part will automatically appear lighter in tone and may appear to change colour, although in fact they do not do so. It is not proposed to refer to the effects which may be produced by fluorescence, as that would give scope for a paper in itself, but the advent of mercury lamps with their output of long-wave ultra-violet light, combined with the fact that very many of the materials used in general decorative practice fluoresce

to a greater or less degree under light of such wavelengths, indicates that this also is a field worthy of the decorative designer's consideration.

Surface Texture.

So much for the phenomena of specular and diffuse reflection of white and coloured light. Consider now a quite different type of factor which affects the appearance of objects, namely, their surface texture. Diffuse and specular reflecting properties are primarily dependent on surface texture, and it is due to slight unevenness of specular surfaces that we get the phenomenon previously described as spread specular reflection under which the light source is reflected substantially in the anticipated direction, but is indicated not by a clear cut image of the source but rather as an area of higher brightness. Visually appreciable unevenness of a surface may clearly have a very marked effect on its appearance if it is of a specularly reflecting nature. It has already been shown that for a given angle of illumination a flat specular surface will appear bright from one angle and dark from all others. If, however, the specular surface is not flat but has many facets at different angles, as in the case of an uneven surface, then clearly the number of directions in which high lights, i.e., specular images of the source, will appear, are greatly increased. In an extreme case, if the high lights were exceptionally bright in comparison with the dark areas between, the effect generally known as "sparkle" would result. Irregularities of surface may, however, under certain conditions create light and shade effects which are quite independent of the reflection properties of the surface as a whole. For example, the weave of a cloth may be such that at certain angles of lighting the threads pick up the light on one side and are in shadow on the other, thus emphasising the pattern of the weave. Embossed effects on fabrics or papers can be emphasised or practically obliterated.

Questions of shape and the appearance of light and shade that result therefrom are quite sufficient to affect the whole appearance of such materials, but it is also interesting to consider at what stage irregularities of surface cause a material made up of specularly reflecting parts to appear as a diffusely reflecting whole. It is all a question of the minimum size of particle which the eye can resolve as a separate object. For instance, if one imagines a surface made up of a lot of brightly polished pimples, so long as the pimples are small enough one will not see them as individual specularly reflecting units, but the multiplicity of beams reflected in any and every direction will give the effect of a diffusely reflecting surface. Increase the size of each pimple, however, and one will soon arrive at a stage where separate clearly defined specular images appear in each. It follows that the appearance of material of such a nature is directly dependent on the distance from which it is viewed. This can be very simply demonstrated by means of ordinary ball bearings spread evenly over a flat surface and illuminated by a directional beam of white light. When the ball bearings are large, a separate specular image of the source appears on one part of each ball while the surrounding parts remain black, as no light is reflected from them to the eye. With smaller balls, however, the white and black portions appear to merge giving the appearance of a matt grey surface.

Taking into consideration these basic principles involved in considering the appearance of decorative materials under artificial light, can such materials be classified in any way which will enable designers to visualise their probable appearance under different lighting systems? Practically all such materials are of a complex nature, depending for their appearance in varying proportions on specular and diffuse reflection properties, surface texture and colour, while they are liable to be used under a wide variety of lighting systems, ranging from the most highly diffused to the most directly concentrating. The difference between such systems of lighting and the single beam of light, which has been considered, is that the system is made up of multitudinous beams converging on any one spot from many angles. The number of beams and the variety of directions from which they come depends upon the system employed, but each one will affect the decorations in the way previously described. The more diffused the lighting system, the greater the number of beams converging on any one spot, and the greater the variety of angles from which they converge.

Gloss.

Many terms are used in describing materials, for example, glossy, lustrous and sparkling, but, with the possible exception of glossy, these terms have no scientific meaning. The question of gloss has been investigated with regard to most of the types of materials discussed, but from a manufacturer's rather than a user's point of view, and it is doubtful whether any of the recognised methods of determining gloss goes far enough to help in describing materials in which gloss is only one of the factors. It may, however, be interesting to see how many different ways there are of estimating gloss alone, because. from the decorator's point of view, each of these methods of estimation is related to gloss in a different apparent form. R. S. Hunter gives as a definition of gloss: "the gloss of a sample is the ability of a surface to reflect light regularly," and goes on to say that it may be recognised in five different ways: (1) objective gloss, namely, the percentage of regular reflection obtained; (2) subjective gloss, which is a comparison between the specular and diffuse reflection; (3) sharpness of reflected images; (4) the presence or absence of bloom; (5) depth of surface; and, with the exception of the last, relative gloss factors may be computed under each method of recognition. The difficulty is that any or all of these phenomena may be of practical interest to the decorator, but the gloss factor under the different systems might be entirely different and he would have to have four separate factors or classifications for this phenomenon alone.

The degree to which the appearances normally associated with gloss are bound up with surface texture can be illustrated in rather an interesting way. It was suggested to the author that as the principal manifestations of gloss appeared in the form of areas of high surface brightness, it ought to be possible to create an appearance of gloss synthetically by deliberately throwing high lights on to sections of

a non-glossy surface. An experiment was therefore tried on a piece of closely-woven white muslin, looped in festoons, so as to create areas of high brightness when flooded with light from the sides. When this illumination was applied to the front surface, a momentary illusion of gloss was created, but it was spoilt by the fact that the texture of the muslin was clearly definable as a matt surface. When, however, the illumination was applied from behind, the surface texture on the front ceased to be visible but the high lights remained and a very striking imitation of a glossy surface resulted.

Another example of synthetic gloss is provided in the cinema. Though the screen is usually by nature a diffuse reflector, the appearance of gloss on objects is in many cases convincingly reproduced.

Classification of Surfaces.

The materials whose appearance is most affected by lighting, and appear to have the greatest vitality under suitable lighting, prove on examination to have either a pronounced texture which can be given a three-dimensional value or else have a mixture of areas of greater or less specular reflecting capacity, so that without necessarily having any variation in colour, high lights and dark patches are created according to the angle of incidence of the light relative to the observer's eye. It is often to be observed with the latter type of material that the contrasts tend to alter either from side to side or top to bottom of the material, a dark pattern on a light background changing to a light pattern on a dark ground. In such cases there is usually a sort of no-man's-land in the middle, where the pattern almost disappears into the background.

Nature of surface of material.	Typical instances of where such surfaces occur.	Suggested lighting system to show material to advantage.	Remarks.
"All over" glossy surfaces...	Glossy paints, vitrite, polished wood, moulded composition panels, etc. ...	Large area low surface brightness sources ...	To avoid specular images of high bright-ness sources
"All over" matt surfaces	Matt paints and fabrics	Appearance relatively unaffected by lighting system	—
Mixed matt and glossy surfaces with relatively large bright image areas ...	Display papers. Metal panelling.	Generally diffused system	To avoid excessive bright and dark contrasts in glossy areas
Mixed matt and glossy surfaces where glossy areas are in form of small spots or lines or where specular reflection is of spread variety	Wall-papers, leather, cloth materials and fabrics	Directional lighting from side or above ...	Such a surface appears to gain vitality by the emphasis which directional lighting gives to glossy areas
Surfaces with embossed pictorial patterns...	Wall-papers, stippled surfaces, fabrics ...	Directional lighting at not too oblique angle	To bring out 3-dimensional appearance without casting shadows deep enough to blur pattern
"All over" rough surfaces...	Wall-papers, stippled surfaces, fabrics ...	Directional lighting up to quite oblique angles	To give vitality and depth

After examining practical examples it seems that the furthest extent to which it is possible to make classifications is somewhat on the lines of the scheme shown in preceding column.

These suggestions, which ignore the question of the colour of the light, should only be taken as a rough guide on which to base preliminary experiments and are not intended to cover special effects. For instance, decorative schemes have been carried out where high gloss areas have been arranged in conjunction with locally concealed lamps to give a deliberate pattern of bright specular reflections. Such an arrangement may clearly be very effective if the specular reflections are controlled, but the danger is that quite unexpected and unwanted reflections may appear from some forgotten source and wreck the pattern.

Where it is desired to use coloured light, if white or lightly coloured surfaces are being illuminated, the colour of light to be selected becomes purely one of taste. Where highly coloured surfaces are involved, it must be remembered that some colour distortion is likely to occur, and the colour of light should be selected by test if necessary to enhance the colour on the materials. Above all, unless and until further investigation of the subject produces more reliable and easily applicable rules of procedure, one can only suggest that those responsible for decorative schemes should examine their decorative materials under the system of lighting they propose to employ before making a final decision, and while if necessary either materials or lighting may be altered to set off each other's good points. Such preliminary try-outs to be effective must be done on a reasonably large scale, as only by so doing can the varying effects be observed from all angles of vision, and such phenomena as additional specular reflection or gloss at oblique angles be noticed.

Finally, it should be made clear that the author has tried to consider the problem from the point of view of showing any given type of decorative material to the best advantage. In many cases a room may be decorated with one of the categories of material scheduled but it may not be practicable or desirable to carry out the whole of the lighting by the method suggested, which in some cases would amount to lighting the room by light reflected off the decorations. It is suggested, however, that while in categories 1 and 3 of the schedule it is highly desirable that the general illumination should, if possible, be

of the type described, in categories 4, 5, and 6, the specially suggested systems of illumination might well be auxiliary to some other general system and would still as a rule serve the desired purpose of enhancing the decorations. Already some decorative designers are arranging the weave of fabrics, etc., in such a way as to give deliberately contrived contrasting effects, and one can visualise the time when advanced decorative designers will use light not only to give illumination or as a form of auxiliary decoration, but as a direct accessory to the attractive display of other decorative materials.

Acknowledgments.

In conclusion, the author wishes to express his thanks to the very many people who have helped with the preparation of this paper and the demonstrations that accompany it, particularly Mr. Jones and the staff of the E.L.M.A. Lighting Service Bureau who helped with the arrangement of the demonstrations, Messrs. I.C.I., John Line and Sons, Arthur Sanderson and Sons, the Strand Electric, and the C.S.S.A., who assisted with materials for the demonstrations, and last, but not least, his colleagues in the General Electric Company, Ltd., at Wembley and Kingsway.

DISCUSSION

Mr. A. W. BEUTTELL said that although it was obvious that a good deal had been left unsaid in the paper, it was an eye-opener to many people, including himself. The paper opened up new possibilities and new lines of thought and very likely new methods of treatment. One of the most interesting points brought out was the effects to be obtained from the lighting of walls concerning which very little attempt had been made in this country hitherto. Mr. Ackerley had rather severely left daylight out of the paper. A few years ago the British Colour Council compiled what was called a Colour Dictionary in which the colours were all specified very accurately, spectrally, chemically, and otherwise, and specifications were given for the necessary dyes. Some 200 colours were thus treated, and there was the possibility of this being a basis for colour display, matching, reproduction, and even the transmission of colour descriptions by telegraphy, a thing which would probably be brought more into use in the future. The Society had asked the British Colour Council whether it had treated these colours from the point of view of their effect under artificial light, and the answer had been that this had not been done. The Colour Dictionary was purely a Dictionary of colour as seen by ordinary daylight. The Society had raised the point as to the possibility of selecting some standard of colours under artificial light which might represent what was done in practice, and would reproduce a range of colours which, under artificial light, would correspond to daylight colours. The British Colour Council was not able to do that because of the financial burden involved, but he still hoped it would be done, perhaps by the Society or in collaboration with the Society, because it would be a very useful forerunner of a scheme which must come sooner or later when electric discharge lamps came more into use.

Another matter of great interest raised in the paper was the reflection of light from a specular surface, such as a varnish or glass, and he hoped some research would be made into it. Personally, he was only familiar with part of the subject, but the point was, that if one drew a graph of the percentage of light reflected from a glass surface it would be seen that the percentage of light reflected from the first surface started at about 4 per cent. and went along with little change, but it then suddenly took an upward turn and reached 100 per cent., glass being a perfect reflector when the light was sliding along the glass. Then there was light reflected from the second surface of the glass, and in that case the curve started at about the same point, rose a little, and then fell again. By adding the two curves together one found the total amount of light reflected from the two surfaces, and a curve of that nature enabled one to know at any angle of incidence approximately what light was reflected from the two surfaces, and it explained a great deal of the phenomena which the author had referred to.

Another point related to a completely polished metal specular surface with a varnish in front of it. Reflected light from the first surface would be white, but if the under surface was coloured, as in the case of copper, it would be found that the light gradually changed from white and became coloured. Perhaps the author could deal with that in his reply.

Mr. F. P. BENTHAM said that the author had put forward a series of exhibits which gave much food for thought.

It seemed to him that the tendency in lighting, especially the white lighting from concealed sources, was to suggest coldness and sadness. Rich lighting was difficult to obtain. Light projected on broken surfaces was more human, and when projected on a regular patterned surface a feeling of richness and warmth was produced. The present-day architectural lighting schemes almost completely ignored this fact. In nature there were very few instances where one colour of light was presented evenly over a large surface. When this was so, the human reaction was always unfavourable. To his mind there was nothing more inhuman than a ceiling evenly lit from concealed sources. The solution lay in more use of patterned surfaces as a diffuser for concealed lighting. This fact had been known in the theatre for some time. No matter how rich the pile on a set of curtains; when illuminated by full up stage, their richness was lost. There were two ways of getting over this difficulty, either by a flecked pattern in two different colours, or by brushing the pile in different directions. The effect of brushed velour was quite extraordinary in its richness. Furthermore, the directional brushing rendered the curtain selective to light from different directions. For instance, if the curtain was illuminated in blue from the top and red

from the bottom, the pattern of the brushing stood out from its background in these two colours. Materials such as artificial silk, that had been put through a process of crushing, took on the appearance of very thick materials.

Referring to the muslin curtain exhibited by the author, it was one of a pair he had had before him for five years. When treating them under front lighting for Mr. Ackerley the other day, it became apparent that one was a cheaper quality than the other, although they had both been bought as identical curtains. He thought this was a good example of the revealing powers of directional light.

Mr. C. O. MASTERS, commenting on the emphasis laid by the author on the need for close collaboration between the decorative expert and the lighting expert, asked who was to have the final word, the decorative expert or the lighting expert? It seemed to him that the two duties should devolve on the same person or that a very close understanding should be arrived at beforehand as to what kind of advice was to be given to a customer. Referring to one or two instances that had come under his notice in connection with light and colour, he mentioned a Harley-street specialist who wanted to redecorate his consulting room because having always had green walls he said he found it difficult to see exactly what his patients really looked like. They usually seemed to look too well! Continuing, he said the author had almost proved to him that there was no such thing as independent colour, and that colour was purely relative. In his firm's showrooms there were two bays similarly lighted and with the same brown carpet in each. In one bay the walls were green and in the other fawn but the carpet showed up entirely differently on account of its surroundings. In showrooms he had found it most satisfactory to have a general diffused light and then to use standard or table lamps at special points to give interesting colours and shadows. Most people, although they did not know it, require to see a very little of anything. For instance, if a room contained a red curtain only sufficient of it need be clearly seen to show it was red, and it became a valuable jewel point of concentrated interest. He thought it necessary to practise economy in the volume of light and colour if these were to be properly appreciated.

Mr. W. G. RAFFÉ recalled having been invited to a meeting of the Society some fifteen years ago by the late Mr. Gaster, when the subject of Stage Lighting was discussed, a subject in which he, as an artist, was very interested. For many years he had carried out experiments on similar lines to those described, although, unfortunately, without the resources which Mr. Ackerley had. The paper concentrated on what had been done with artificial light; about a century ago a very fine artist named Chevreul was employed to solve somewhat similar problems in connection with certain Gobelin tapestries which were being returned as unsatisfactory in colouring light. In self-defence the manufacturers were compelled to study colour, and they commissioned Chevreul, who wrote a book on the subject. This, believed the speaker, was the first book published on colour research. Had Chevreul been able to make use of electric light no doubt he would have arrived at similar principles to those which Mr. Ackerley had mentioned. Later on Claude Monet painted a haystack sixty times under different illumination in order to see the effects of colour; and subsequently Seurat painted pictures which showed that if spots of colour—red, blue, yellow, and green—were placed side by side on a canvas they "blended in the eye" a short distance away. A very much richer effect was thus obtained than by mixing the paints previously on a palette. Only to-day we were experimentingly mixing colours in lighting, and this showed that insufficient attention was being paid by the designers of illuminating schemes to the other arts, such as painting, on the lines Seurat had indicated. That also was a matter to which J. M. W. Turner, the famous painter, always paid great attention. The question of scale came in; that had been demonstrated by the large and small ball bearings exhibited by the author.

An interesting point he had noted in painting, long ago, was that specular reflection and diffuse reflection occurred simultaneously from the same surface; the apparent effect was solely a question of the point of view of the observer with the angle of incidence of the light. This had been noted by many painters; and in painting the reflection of an object in water or in glass they noted it was not possible to give a tone equal to 100 per cent. of the incident light.

Speaking of lacquering highly polished metal surfaces Mr. Raffé said, as this used to be one of his experimental jobs, he could say quite definitely that the invariable result was to diminish the amount of reflection from any lacquered metal surface, because the lacquer, however hard it might be, was never as smooth or level as the polished metal surface; and, therefore, the reflection was diminished. Another important fact in this connection was that such glossy surfaces of metal, if left unlacquered, did not "stay put," especially in our climate, and what was at first a brilliant surface subsequently went dull. This is noted even for hard metals—nickel or chromium, though they do not oxydise as rapidly as polished steel or copper.

Continuing, Mr. Raffé said he would like to see experiments carried out in mixing projected rays of light, not through air, but entirely through some neutral gas, such as helium or neon, because he was inclined to think that the results would be very different as compared with passing the light through air.

Speaking of the British Colour Council, he suggested that colour principles are being worked out wrongly; the aim should be to get some *unit* of measurement which could be applied to any colour or any sensation of colour just as the foot rule was used in other measurements. He contended that at present there was no such thing as colour measurement, because there is more reliance on the possession of indexed "samples," or because some elaborate

mechanism is necessary. None of these gives a real scientific *abstract* unit such as yard, hour, litre, ohm, or volt.

Mr. J. S. Dow (Hon. Secretary) referred to a practical point in places where flimsy paper was used in conjunction with copying-ink pencils. The paper was glazed and the surface of the ink was glossy, and it was impossible to get a desirable contrast. Illuminating engineers and artists should protest against the use of copying-ink pencils.

In connection with the indirect lighting of ceilings he said that where there were glossy patterns there were frequently unsightly patches of light reflection in certain parts of the room which architects never visualised or expected. On the other hand, he had noticed that with the indirect lighting of a frieze or a moulded pattern it was possible to relieve the monotony if the pattern was shown up in a rather vivid way.

An interesting point with regard to colour in houses arose in connection with the choice of flowers. The floral effect might be completely spoiled for the evening, if the flowers were selected in the day time. Incidentally—apart from colour effects—it was rarely possible to get such good effects by daylight as by artificial light, as the flowers in a room rarely appeared sufficiently bright in comparison with their surroundings.

No mention was made by the author of the colour effects arising from fluorescence. Fluorescence in that it was possible to obtain a greater brightness than that afforded by the source itself. In principle the phenomenon was also important, because there was an actual change in colour—not merely a subtraction of light—involved. Fluorescence effects were already being used in exhibitions. He believed that at the Golden Gate Exhibition, at San Francisco, a big feature was being made of them. It has also been suggested that fluorescence might be useful in homes when the latest types discharge lamps came into general use for interior purposes.

Mr. J. G. Christopher remarked that if one lighted a coloured fabric with ordinary continuous spectrum incandescent light the various colours would appear to be " flat " and lacking in contrast. If, however, the same fabric was lighted with white light of approximately the same colour, but obtained by blending two or three semi-monochromatic luminous tubes, the colours appeared to stand out in a much more pronounced manner.

This bore out the idea that had been mentioned of spots of intense colour on a canvas merging and giving a better effect than a composite colour.

Mr. G. H. Wilson referred again to the colour atlas which Mr. Beuttell had mentioned. He said it was not on the atlas as such that he wished to comment but on the materials used for showing the colours. He felt they presented a problem touching on the response of materials to light with which Mr. Ackerley had been dealing. As far as he remembered, the fabrics used in the atlas were shiny so that specular reflection could be obtained from the surface. If these colours were viewed so that the specularly reflected light reached the eye, then, as Mr. Ackerley had shown, the true colour would be diluted with the specularly reflected white light. Mr. Wilson concluded by saying he was surprised that matt fabrics had not been used for the atlas.

Mr. J. S. Preston referred to Mr. Beuttell's remarks, in which he drew attention to the change in the *amount* of light specularly reflected from a glossy surface as the angle of incidence was changed, and said there was another case in which the *colour* of the light would change. This was in the interference effect shown by certain butterfly's wings or by a thin film of oil floating on water. Had any use been made of this effect in decorative work?

The Chairman said that the paper had interested him considerably, as in the course of his work it was his misfortune to come into contact with nearly every branch of industry, with the result that he had become something of a jack of most trades without going very far into any one. Therefore he was always extremely interested to come into touch with people who were going deeply into different aspects of these problems, for it taught him how valuable was the scientific and technical work that they did in serving the ordinary needs of the public. He could not help feeling that this paper was very opportune, because there was a steadily growing attention being paid to home decoration, and this would increase with the cheapening of the cost of light, and, of course, homes represented by far the largest consumer of decorative materials and perhaps the most important. Moreover, whilst it was true that content in homes was largely based on the temperament of the people in them, he was quite sure that effective decorative treatment would do very much to increase that content.

Mr. H. M. Cotterill, in a communicated contribution, mentioned the instance of a certain civic hall, in which lighting of a somewhat pinkish colour was used. He understood that it had been found necessary to give a corresponding tint to the mirrors in the retiring rooms, where ladies made their preparations for evening events.

One noticed, in shops, an anomaly in the methods pursued. Windows were usually lighted either by means of uncorrected incandescent lamps, or by a mixture of these with " daylight " lamps. Inside the shop, however, where daylight scarcely penetrated, daylight lamps were often installed by the keen shopkeeper so that goods might be examined under " natural " conditions. The fact was overlooked that

evening dresses, whilst being worn, are seldom, if ever, viewed in daylight. They should be inspected under light similar to that by which they will be seen when in use.

Some reference had been made to the method of lighting the walls of a room, so that the reflected light might form at least a portion of the general illumination. This idea had been in use for some time in certain stations on the Underground. He recalled one instance in which the reflected light from illuminated posters was more than adequate to provide general lighting for the station. In a room, however, the position was somewhat different. One was surely more interested in the persons using them than in the articles on the walls, and it would be disturbing if the latter were lighted to such a high degree as to furnish the general illumination. On the other hand, effective results could be obtained by lighting pictures only on the walls and furnishing supplementary illumination from candles or table lamps. The reflected light from such objects as pictures was usually only enough in practice to furnish what might be termed "gangway lighting."

In regard to the question of pile on a velour curtain, he recalled an incident in a certain auditorium where the half of one curtain appeared much darker than the other when illuminated by the footlights. It was discovered that a different type of reflector (metal instead of glass) had been installed at one end of the footlight, and the effect was at first attributed to this oversight. However, when the reflectors were interchanged the effect persisted. It was ultimately proved to be entirely due to the method of preparation of the curtain, which had been sewn up with the pile of the velour lying upwards in one part of it and downwards in another. When viewed by general lighting (as, for example, daylight, under which this curtain was made), the effect was not noticeable. It only revealed itself when the directional light of the footlights was applied.

Mr. R. O. ACKERLEY, replying to the discussion, said it was quite true, as Mr. Beuttell had remarked, that a great deal had been left unsaid in the paper but much of it had been deliberately left out because the subject was altogether too large to be completely treated in one evening. He had not been able to discover, however, that this subject of the combination of light and decoration had ever been really tackled scientifically as one subject before. He agreed with Mr. Raffé that had electric light been available a century ago this subject would have been treated on similar lines then to those indicated in the paper. With regard to the colour code it was to be hoped that the Illuminating Engineering Society would make an effort to get some standardisation of colour in relation to artificial light. There were many places where artificial light had to be used practically all the time and surely it was desirable, in such cases, to choose the decorations by artificial light rather than by daylight. The curve which Mr. Beuttell had shown automatically followed from the curve of specular reflection at varying angles of incidence and although it was practically impossible to give it as a demonstration to a large audience it was possible to get specular reflection off a black bowler hat!

In connection with Mr. Bentham's remarks, the author said there was a large installation on the Continent which took advantage of brushing the nap of velour curtains in different directions to get attractive lighting effects. (Mr. Ackerley gave a demonstration of this effect.)

Commenting on the remarks by Mr. Masters, he said that of course the illuminating engineer would not wish to dominate the position in collaborating with the decorative designer, but it was to be hoped that the decorative designer would take his cue from the illuminating engineer and would make it a practice of getting into touch with somebody who knew something about lighting because the two aspects were intimately bound up together. Mr. Masters was quite right in saying that colour was relative, and that had been dealt with in the paper. The fact that colours which matched in daylight did not match in artificial light was a strong reason for the necessity of a colour code which would permit of matching in artificial light in the same way that colours could at present be matched in daylight. The value of shadow in relieving the monotony of indirect lighting was undoubted and this could be achieved by the use of auxiliary fittings to give a decorative effect. It was, of course, desirable to keep highly specular surfaces to small proportions, but unfortunately that was not always done. One of the worst examples was highly polished panel woodwork in a room, a form of decoration which made it extremely difficult to light such a room.

With regard to Mr. Raffé's suggestion as to the absorption of colour by air and by gases, he would like to ask the scientific people whether that was the cause of the apparently different colours obtained in the contrast between mercury and filtered light at different distances, and whether that was a subject worth any further investigation.

The reference by Mr. Dow to flowers was a very good example of how important it was to look after lighting effects. The question of fluorescence had not been overlooked in the paper; it was referred to but, of course, it would take another paper to deal with it adequately. Almost every material dealt with in ordinary decorative work to-day fluoresced to some extent and, therefore, if light sources containing near ultra-violet radiations were going to be introduced, such as in the case of the high pressure mercury lamps, it was necessary to look out for fluorescent effects which might still further affect the colour of materials or give them extra power of reflecting light which they did not get from other light sources.

With regard to the point mentioned by Mr. Christopher that the mixing of colours to give a white light resulted in a better effect than using a white light direct, Mr. Good and himself had had some

experience of that in floodlighting in connection with the Coronation. It had been found that the white stonework and the red brickwork of Hampton Court Palace showed up much more effectively under a mixture of white and red light than with a red or white light only. Another example was the Dufay colour screen which consisted of small spots of various colours, the resultant effect being akin to white light, and the colours came out very much better.

In conclusion Mr. Ackerley said this was a field which would bear a great deal more investigation and if his efforts resulted in somebody else following the matter up he would be only too happy.

Applications for Membership.

At the general meeting of the Society held on March 1, 1938, the names of the following applicants for membership were presented:—

Elections Pending.

CORPORATE MEMBERS:—

Blakeley, S .....“Nan-Barrie,” Kingsway, Ossett, YORKSHIRE.

Howes, J. K. .....Lustray Products, 294, Grays Inn Road, LONDON, W.C.1.

Roberts, L .....War Office, 73, Strand, LONDON, W.C.2.

Woodrow, V. H. .....26, Hartington Road, Chorlton-cum-Hardy, MANCHESTER.

COUNTRY MEMBERS:—

Charles, R. .....“Carnaby,” Richmond Road, LEEDS, 6.

Fewkes, S. B. .....14, Bingham Park Crescent, SHEFFIELD, 11.

Underwood, P. S. J. ...6, Forest Avenue, Forest Hall, NEWCASTLE-UPON-TYNE.

Vickers, H. N. .....100, Upper Albert Road, Meersbrook, SHEFFIELD, 8.

Elections Completed.

At this meeting the names of those announced on February 8, which were published in the *Transactions* (Vol. III., No. 2, February, 1938, p. 20), were presented again, and these applicants were formally declared members of the Society.

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

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